Chapter 1

Intelligence

Before they can understand how to fight in mountainous environment, commanders must analyze the area of operations (AO), understand its distinct characteristics, and understand how these characteristics affect personnel and equipment. This chapter provides detailed information on terrain and weather necessary to conduct a thorough intelligence preparation of the battlefield (IPB), however, the IPB *process* remains unaffected by mountains (see FM 2-01.3 for detailed information on how to conduct IPB).

SECTION I – THE PHYSICAL ENVIRONMENT

1-1. The requirement to conduct military operations in mountainous regions presents commanders with challenges distinct from those encountered in less rugged environments and demands increased perseverance, strength, will, and courage. Terrain characterized by steep slopes, great variations in local relief, natural obstacles, and lack of

CONTENTS

accessible routes restricts mobility, drastically increases movement times, limits the effectiveness of some weapons, and complicates supply operations. The weather, variable with the season and time of day, combined with the terrain, can greatly affect mobility and tactical operations. Even under nonviolent conditions, operations in a mountainous environment may pose significant risks and dangers.

TERRAIN

1-2. Mountains may rise abruptly from the plains to form a giant barrier or ascend gradually as a series of parallel ridges extending unbroken for great distances. They may consist of varying combinations of isolated peaks, rounded crests, eroded ridges, high plains cut by valleys, gorges, and deep ravines. Some mountains, such as those found in desert regions, are dry and barren, with temperatures ranging from extreme heat in the summer to extreme cold in the winter. In tropical regions, lush jungles with heavy seasonal rains and little temperature variation frequently cover mountains. High, rocky crags with glaciated peaks and year-round snow cover exist in mountain ranges at most latitudes along the western portion of the Americas and in Asia. No matter what form mountains take, their common denominator is rugged terrain.

MOUNTAINOUS REGIONS

1-3. The principal mountain ranges of the world lie along the broad belts shown in Figure 1-1. Called *cordillera*, after the Spanish word for rope, they encircle the Pacific basin and then lead westward across Eurasia into North Africa. Secondary, though less rugged, chains of mountains lie along the Atlantic margins of America and Europe.

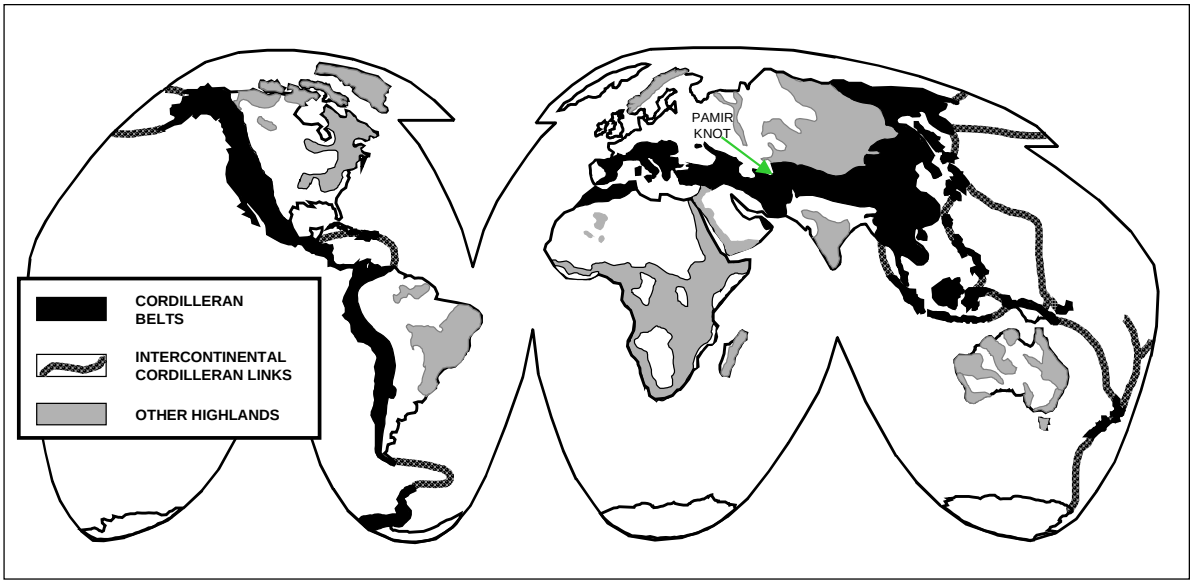

Figure 1-1. Mountain Regions of the World

1-4. A broad mountainous region approximately 1,600 kilometers wide dominates northwestern North America. It occupies much of Alaska, more than a quarter of Canada and the US, and all but a small portion of Mexico and Central America. The Rocky Mountain Range includes extensive high plains and basins. Numerous peaks in this belt rise above 3,000 meters (10,000 feet). Its climate varies from arctic cold to tropical heat, with the full range of seasonal and local extremes.

1-5. Farther south, the Andes stretch as a continuous narrow band along the western region of South America. Narrower than its counterpart in the north, this range is less than 800 kilometers wide. However, it continuously exceeds an elevation of 3,000 meters (10,000 feet) for a distance of 3,200 kilometers.

1-6. In its western extreme, the Eurasian mountain belt includes the Pyrenees, Alps, Balkans, and Carpathian ranges of Europe. These loosely linked systems are separated by broad low basins and are cut by numerous valleys. The Atlas Mountains of North Africa are also a part of this belt. Moving eastward into Asia, this system becomes more complex as it reaches the extreme heights of the Hindu Kush and the Himalayas. Just beyond the *Pamir Knot* on the Russian-Afghan frontier, it begins to fan out across all parts of eastern Asia. Branches of this belt continue south along the rugged island chains to New Zealand and northeast through the Bering Sea to Alaska.

MOUNTAIN CHARACTERISTICS

1-7. Mountain slopes generally vary between 15 and 45 degrees. Cliffs and other rocky precipices may be near vertical, or even overhanging. Aside from obvious rock formations and other local vegetation characteristics, actual slope surfaces are usually found as some type of relatively firm earth or grass. Grassy slopes may include grassy clumps known as *tussocks,* short alpine grasses, or *tundra* (the latter more common at higher elevations and latitudes). Many slopes will be scattered with rocky debris deposited from the higher peaks and ridges. Extensive rock or boulder fields are known as *talus*. Slopes covered with smaller rocks, usually fist-sized or smaller, are called *scree* fields. Slopes covered in talus often prove to be a relatively easy ascent route. On the other hand, climbing a scree slope can be extremely difficult, as the small rocks tend to loosen easily and give way. However, this characteristic often makes scree fields excellent descent routes. Before attempting to descend scree slopes, commanders should carefully analyze the potential for creating dangerous rockfall and take necessary avoidance measures.

1-8. In winter, and at higher elevations throughout the year, snow may blanket slopes, creating an environment with its own distinct affects. Some snow conditions can aid travel by covering rough terrain with a consistent surface. Deep snow, however, greatly impedes movement and requires soldiers well-trained in using snowshoes, skis, and over-snow vehicles. Steep snow covered terrain presents the risk of snow avalanches as well. Snow can pose a serious threat to soldiers not properly trained and equipped for movement under such conditions. Avalanches have taken the lives of more soldiers engaged in mountain warfare than all other terrain hazards combined.

1-9. Commanders operating in arctic and subarctic mountain regions, as well as the upper elevations of the world's high mountains, may be confronted

with vast areas of glaciation. Valleys in these areas are frequently buried under massive glaciers and present additional hazards, such as hidden crevices and ice and snow avalanches. The mountain slopes of these peaks are often glaciated and their surfaces are generally composed of varying combinations of rock, snow, and ice. Although glaciers have their own peculiar hazards requiring special training and equipment, movement over valley glaciers is often the safest route through these areas (TC 90-6-1 contains more information on avalanches and glaciers, and their effects on operations).

MOUNTAIN CLASSIFICATIONS

1-10. There is no simple system available to classify mountain environments. Soil composition, surface configuration, elevation, latitude, and climatic patterns determine the specific characteristics of each major mountain range. When alerted to the potential requirement to conduct mountain operations, commanders must carefully analyze each of these characteristics for the specific mountain region in which their forces will operate. However, mountains are generally classified or described according to their local relief; for military purposes, they may be classified according to operational terrain levels and dismounted mobility and skill requirements.

Local Relief

1-11. Mountains are commonly classified as low or high, depending on their local relief and, to some extent, elevation. Low mountains have a local relief of 300 to 900 meters (1,000 to 3,000 feet) with summits usually below the timberline. High mountains have a local relief usually exceeding 900 meters (3,000 feet) and are characterized by barren alpine zones above the timberline. Glaciers and perennial snow cover are common in high mountains and usually present commanders with more obstacles and hazards to movement than do low mountains.

Operational Terrain Levels

1-12. Mountain operations are generally carried out at three different operational terrain levels (see Figure 1-2). Level I terrain is located at the bottom of valleys and along the main lines of communications. At this level, heavy forces can operate, but maneuver space is often restricted. Light and heavy forces are normally combined, since vital lines of communication usually follow the valley highways, roads, and trails.

Level	Description
I	The bottoms of valleys and main lines of communications
II	The ridges, slopes, and passes that overlook valleys
III	The dominant terrain of the summit region

Figure 1-2. Operational Terrain Levels

1-13. Level II terrain lies between valleys and shoulders of mountains. Generally, narrow roads and trails, which serve as secondary lines of communication, cross this ridge system. Ground mobility is difficult and light forces will expend great effort on these ridges, since they can easily influence operations at Level I. Similarly, enemy positions at the next level can threaten operations on these ridges.

1-14. Level III includes the dominant terrain of summit regions. Although summit regions may contain relatively gentle terrain, mobility in Level III is usually the most difficult to achieve and maintain. Level III terrain, however, can provide opportunities for well-trained units to attack the enemy from the flanks and rear. At this terrain level, acclimatized soldiers with advanced mountaineering training can infiltrate to attack lines of communication, logistics bases, air defense sites, and command infrastructures.

Dismounted Mobility Classification

1-15. When conducting mountain operations, commanders must clearly understand the effect the operational terrain level has on dismounted movement. Therefore, in addition to the general mobility classification contained in FM 2-01.3 (unrestricted, restricted, severely restricted), mountainous terrain may be categorized into five classes based on the type of individual movement skill required (see Figure 1-3). Operations conducted in class 1 and 2 terrain require little to no mountaineering skills. Operations in class 3, 4, and 5 terrain require a higher level of mountaineering skills for safe and efficient movement. Commanders should plan and prepare for mountain operations based, in large part, on this type of terrain analysis.

Class	Terrain	Mobility Requirements	Skill Level Required*
1	Gentler slopes/ trails	Walking techniques	Unskilled (with some assistance) and Basic Mountaineers
2	Steeper/rugged terrain	Some use of hands	
3	Easy climbing	Fixed ropes where exposed	Basic Mountaineers (with assistance from assault climbers)
4	Steep/exposed climbing	Fixed ropes required	
5	Near vertical	Technical climbing required	Assault Climbers
* See Chapter 2 for a discussion of mountaineering skill levels			

Figure 1-3. Dismounted Mobility Classification

WEATHER

1-16. In general, mountain climates tend to be cooler, wetter versions of the climates of the surrounding lowlands. Most mountainous regions exhibit at least two different climatic zones – a zone at low elevations and another at elevations nearer the summit regions. In some areas, an almost endless variety of local climates may exist within a given mountainous region. Conditions change markedly with elevation, latitude, and exposure to atmospheric winds and air masses. In addition, the climatic patterns of two ranges located at the same latitude may differ radically.

1-17. Like most other landforms, oceans influence mountain climates. Mountain ranges in close proximity to oceans and other large bodies of water usually exhibit a *maritime climate.* Maritime climates generally produce milder temperatures and much larger amounts of rain and snow. Their relatively mild winters produce heavy snowfalls, while their summer temperatures

rarely get excessively hot. Mountains farther inland usually display a more *continental climate.* Winters in this type climate are often bitterly cold, while summers can be extremely hot. Annual rain- and snowfall here is far less than in a maritime climate and may be quite scarce for long periods. Relatively shallow snow-packs are normal during a continental climate's winter season.

1-18. Major mountain ranges force air masses and storm systems to drop significant amounts of rain and snow on the windward side of the range. As air masses pass over mountains, the leeward slopes receive far less precipitation than the windward slopes. It is not uncommon for the climate on the windward side of a mountain range to be humid and the climate on the leeward side arid. This phenomenon affects coastal mountains, as well as mountains farther inland. The deepest winter snow-packs will almost always be found on the windward side of mountain ranges. As a result, vegetation and forest characteristics may be markedly different between these two areas. Prevailing winds and storm patterns normally determine the severity of these effects.

1-19. Mountain weather can be erratic, varying from strong winds to calm, and from extreme cold to relative warmth within a short time or a minor shift in locality. The severity and variance of the weather require soldiers to be prepared for alternating periods of heat and cold, as well as conditions ranging from dry to extremely wet. At higher elevations, noticeable temperature differences may exist between sunny and shady areas or between areas exposed to wind and those protected from it. This greatly increases every soldier's clothing load and a unit's overall logistical requirements. Figure 1-4 summarizes the effects of mountain weather discussed below. FM 2-33.201 and FM 3-97.22 contain additional information on how weather affects operations.

TEMPERATURE

1-20. Normally, soldiers encounter a temperature drop of three to five degrees Fahrenheit per 300-meter (1,000-foot) gain in elevation. In an atmosphere containing considerable water vapor, the temperature drops about one degree Fahrenheit for every 100-meter (300-foot) increase. In very dry air, it drops about one degree Fahrenheit for every 50 meters (150 feet). However, on cold, clear, and calm mornings, when a troop movement or climb begins from a valley, soldiers may encounter higher temperatures as they gain elevation. This reversal of the normal situation is called temperature inversion. Additionally, during winter months, the temperature is often higher during a storm than during periods of clear weather. However, the dampness of precipitation and penetration of the wind may still cause soldiers to chill faster. This is compounded by the fact that the cover afforded by vegetation often does not exist above the tree-line. Under these conditions, commanders must weigh the tactical advantage of retaining positions on high ground against seeking shelter and warmth at lower elevations with reduced visibility.

1-21. At high elevations, there may be differences of 40 to 50 degrees Fahrenheit between the temperature in the sun and that in the shade. This is similar in magnitude to the day-to-night temperature fluctuations experienced in some deserts (see FM 3-97.3). Besides permitting rapid heating, the

clear air at high altitudes also results in rapid cooling at night. Consequently, temperatures rise swiftly after sunrise and drop quickly after sunset. Much of the chilled air drains downward so that the differences between day and night temperatures are greater in valleys than on slopes.

Weather Condition	Flat to Moderate Terrain Effects	Added Mountain Effects
Sunshine	• Sunburn • Snow blindness • Temperature differences between sun and shade	• Increased risk of sunburn and snow blindness • Severe, unexpected temperature variations between sun and shade • Avalanches
Wind	• Windchill	• Increased risk and severity of windchill • Blowing debris or driven snow causing reduced visibility • Avalanches
Rain	• Reduced visibility • Cooler temperatures	• Landslides • Flash floods • Avalanches
Snow	• Cold weather injuries • Reduced mobility and visibility • Snow blindness • Blowing snow	• Increased risk and severity of common effects • Avalanches
Storms	• Rain/snow • Reduced visibility • Lightning	• Extended duration and intensity greatly affecting visibility and mobility • Extremely high winds • Avalanches
Fog	• Reduced mobility/visibility	• Increased frequency and duration
Cloudiness	• Reduced visibility	• Greatly decreased visibility at higher elevations

Figure 1-4. Comparison of Weather Effects

WIND

1-22. In high mountains, the ridges and passes are seldom calm. By contrast, strong winds in protected valleys are rare. Normally, wind velocity increases with altitude and is intensified by mountainous terrain. Valley breezes moving up-slope are more common in the morning, while descending mountain breezes are more common in the evening. Wind speed increases when winds are forced over ridges and peaks (orographic lifting), or when they funnel through narrowing mountain valleys, passes, and canyons (Venturi effect). Wind may blow with great force on an exposed mountainside or summit. As wind speed doubles, its force on an object nearly quadruples.

1-23. Mountain winds cause rapid temperature changes and may result in blowing snow, sand, or debris that can impair movement and observation. Commanders should routinely consider the combined cooling effect of ambient temperature and wind (windchill) experienced by their soldiers (see Figure 1-5 on page 1-8). At higher elevations, air is considerably dryer than air at sea level. Due to this increased dryness, soldiers must increase their fluid

intake by approximately one-third. However, equipment will not rust as quickly, and organic matter will decompose more slowly.

WIND SPEED		COOLING POWER OF WIND EXPRESSED AS "EQUIVALENT CHILL TEMPERATURE"																				
KNOTS	MPH	TEMPERATURE (°F)																				
CALM	CALM	40	35	30	25	20	15	10	5	-0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60
		EQUIVALENT CHILL TEMPERATURE																				
3-6	5	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-70
7-10	10	30	20	15	10	5	0	-10	-15	-20	-25	-35	-40	-45	-50	-60	-65	-70	-75	-80	-90	-95
11-15	15	25	15	10	0	-5	-10	-20	-25	-30	-40	-45	-50	-60	-65	-70	-80	-85	-90	-100	-105	-110
16-19	20	20	10	5	0	-10	-15	-25	-30	-35	-45	-50	-60	-65	-75	-80	-85	-95	-100	-110	-115	-120
20-23	25	15	10	0	-5	-15	-20	-30	-35	-45	-50	-60	-65	-75	-80	-90	-95	-105	-110	-120	-125	-135
24-28	30	10	5	0	-10	-20	-25	-30	-40	-50	-55	-65	-70	-80	-85	-95	-100	-110	-115	-125	-130	-140
29-32	35	10	5	-5	-10	-20	-30	-35	-40	-50	-60	-65	-75	-80	-90	-100	-105	-115	-120	-130	-135	-145
33-36	40	10	0	-5	-15	-20	-30	-35	-45	-55	-60	-70	-75	-85	-95	-100	-110	-115	-125	-130	-140	-150
WINDS ABOVE 40 HAVE LITTLE ADDITIONAL EFFECT		LITTLE DANGER					INCREASING DANGER (Flesh may freeze within 1 minute)						GREAT DANGER (Flesh may freeze within 30 secs)									

Figure 1-5. Windchill Chart

PRECIPITATION

1-24. The rapid rise of air masses over mountains creates distinct local weather patterns. Precipitation in mountains increases with elevation and occurs more often on the windward than on the leeward side of ranges. Maximum cloudiness and precipitation generally occur near 1,800 meters (6,000 feet) elevation in the middle latitudes and at lower levels in the higher latitudes. Usually, a heavily wooded belt marks the zone of maximum precipitation.

Rain and Snow

1-25. Both rain and snow are common in mountainous regions. Rain presents the same challenges as at lower elevations, but snow has a more significant influence on all operations. Depending on the specific region, snow may occur at anytime during the year at elevations above 1,500 meters (5,000 feet). Heavy snowfall greatly increases avalanche hazards and can force changes to previously selected movement routes. In certain regions, the intensity of snowfall may delay major operations for several months. Dry, flat riverbeds may initially seem to be excellent locations for assembly areas and support activities, however, heavy rains and rapidly thawing snow and ice may create flash floods many miles downstream from the actual location of the rain or snow.

Thunderstorms

1-26. Although thunderstorms are local and usually last only a short time, they can impede mountain operations. Interior ranges with continental climates are more conducive to thunderstorms than coastal ranges with maritime climates. In alpine zones, driving snow and sudden wind squalls often accompany thunderstorms. Ridges and peaks become focal points for lightning strikes, and the occurrence of lightning is greater in the summer than the winter. Although statistics do not show lightning to be a major mountaineering hazard, it should not be ignored and soldiers should take normal precautions, such as avoiding summits and ridges, water, and contact with metal objects.

Traveling Storms

1-27. Storms resulting from widespread atmospheric disturbances involve strong winds and heavy precipitation and are the most severe weather condition that occurs in the mountains. If soldiers encounter a traveling storm in alpine zones during winter, they should expect low temperatures, high winds, and blinding snow. These conditions may last several days longer than in the lowlands. Specific conditions vary depending on the path of the storm. However, when colder weather moves in, clearing at high elevations is usually slow.

Fog

1-28. The effects of fog in mountains are much the same as in other terrain. However, because of the topography, fog occurs more frequently in the mountains. The high incidence of fog makes it a significant planning consideration as it restricts visibility and observation complicating reconnaissance and surveillance. However, fog may help facilitate covert operations such as infiltration. Routes in areas with a high occurrence of fog may need to be marked and charted to facilitate passage.

SECTION II – EFFECTS ON PERSONNEL

1-29. The mountain environment is complex and unforgiving of errors. Soldiers conducting operations anywhere, even under the best conditions, become cold, thirsty, tired, and energy-depleted. In the mountains however, they may become paralyzed by cold and thirst and incapacitated due to utter exhaustion. Conditions such as high elevations, rough terrain, and extremely unpredictable weather require leaders and soldiers who have a keen understanding of environmental threats and what to do about them.

1-30. A variety of individual soldier characteristics and environmental conditions influence the type, prevalence, and severity of mountain illnesses and injuries (see Figure 1-6 on page 1-10). Due to combinations of these characteristics and conditions, soldiers often succumb to more than one illness or injury at a time, increasing the danger to life and limb. Three of the most common, cumulative, and subtle factors affecting soldier ability under these variable conditions are nutrition (to include water intake), decreased oxygen due to high altitude, and cold. Preventive measures, early recognition, and

rapid treatment help minimize nonbattle casualties due to these conditions (see Appendix A for detailed information on mountain-specific illnesses and injuries).

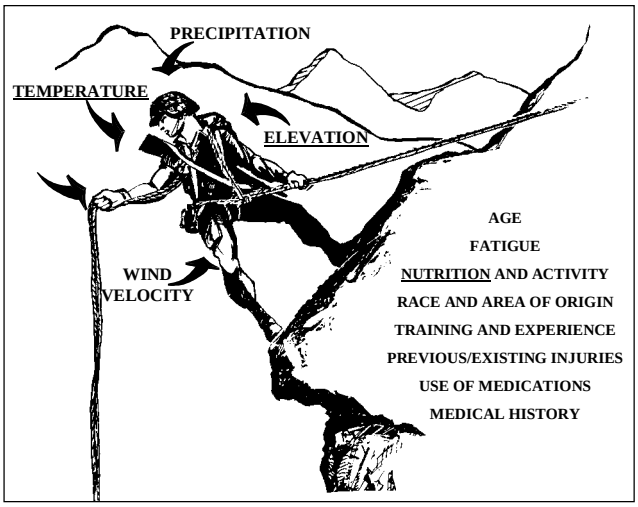

Figure 1-6. Environmental and Soldier Conditions Influencing Mountain Injuries and Illnesses

NUTRITION

1-31. Poor nutrition contributes to illness or injury, decreased performance, poor morale, and susceptibility to cold injuries, and can severely affect military operations. Influences at high altitudes that can affect nutrition include a dulled taste sensation (making food undesirable), nausea, and lack of energy or motivation to prepare or eat meals.

1-32. Caloric requirements increase in the mountains due to both the altitude and the cold. A diet high in fat and carbohydrates is important in helping the body fight the effects of these conditions. Fats provide long-term, slow caloric release, but are often unpalatable to soldiers operating at higher altitudes. Snacking on high-carbohydrate foods is often the best way to maintain the calories necessary to function.

1-33. Products that can seriously impact soldier performance in mountain operations include:

- *Tobacco*. Tobacco smoke interferes with oxygen delivery by reducing the blood's oxygen-carrying capacity. Tobacco smoke in close, confined spaces increases the amounts of carbon monoxide. The irritant effect of tobacco smoke may produce a narrowing of airways, interfering with optimal air movement. Smoking can effectively raise the "physiological altitude" as much as several hundred meters.
- *Alcohol*. Alcohol impairs judgement and perception, depresses respiration, causes dehydration, and increases susceptibility to cold injury.
- *Caffeine*. Caffeine may improve physical and mental performance, but it also causes increased urination (leading to dehydration) and, therefore, should be consumed in moderation.

1-34. Significant body water is lost at higher elevations from rapid breathing, perspiration, and urination. Depending upon level of exertion, each soldier should consume about four to eight quarts of water or other decaffeinated fluids per day in low mountains and may need ten quarts or more per day in high mountains. Thirst is not a good indicator of the amount of water lost,

and in cold climates sweat, normally an indicator of loss of fluid, goes unnoticed. Sweat evaporates so rapidly or is absorbed so thoroughly by clothing layers that it is not readily apparent. **When soldiers become thirsty, they are already dehydrated**. Loss of body water also plays a major role in causing altitude sickness and cold injury. Forced drinking in the absence of thirst, monitoring the deepness of the yellow hue in the urine, and watching for behavioral symptoms common to altitude sickness are important factors for commanders to consider in assessing the water balance of soldiers operating in the mountains.

1-35. In the mountains, as elsewhere, refilling each soldier's water containers as often as possible is mandatory. No matter how pure and clean mountain water may appear, water from natural sources should always be purified or chemically sterilized to prevent parasitical illnesses (giardiasis). Commanders should consider requiring the increased use of individual packages of powdered drink mixes, fruit, and juices to help encourage the required fluid intake.

ALTITUDE

1-36. As soldiers ascend in altitude, the proportion of oxygen in the air decreases. Without proper acclimatization, this decrease in oxygen saturation can cause altitude sickness and reduced physical and mental performance (see Figure 1-7). Soldiers cannot maintain the same physical performance at high altitude that they can at low altitude, regardless of their fitness level.

Altitude	Meters	Feet	Effects
Low	Sea Level – 1,500	Sea Level – 5,000	None.
Moderate	1,500 – 2,400	5,000 – 8,000	Mild, temporary altitude sickness may occur
High	2,400 – 4,200	8,000 – 14,000	Altitude sickness and decreased performance is increasingly common
Very High	4,200 – 5,400	14,000 – 18,000	Altitude sickness and decreased performance is the rule
Extreme	5,400 – Higher	18,000 - Higher	With acclimatization, soldiers can function for short periods of time

Figure 1-7. Effects of Altitude

1-37. The mental effects most noticeable at high altitudes include decreased perception, memory, judgement, and attention. Exposure to altitudes of over 3,000 meters (10,000 feet) may also result in changes in senses, mood, and personality. Within hours of ascent, many soldiers may experience euphoria, joy, and excitement that are likely to be accompanied by errors in judgement, leading to mistakes and accidents. After a period of about 6 to 12 hours, euphoria decreases, often changing to varying degrees of depression. Soldiers may become irritable or may appear listless. Using the buddy system during this early exposure helps to identify soldiers who may be more severely affected. High morale and esprit instilled before deployment and reinforced frequently help to minimize the impact of negative mood changes.

1-38. The physical effect most noticeable at high altitudes includes vision. Vision is generally the sense most affected by altitude exposure and can potentially affect military operations at higher elevations. Night vision is significantly reduced, affecting soldiers at approximately 2,400 meters (8,000 feet) or higher. Some effects occur early and are temporary, while others may persist after acclimatization or even for a period of time after descent. To compensate for loss of functional abilities, commanders should make use of tactics, techniques, and procedures that trade speed for increased accuracy. By allowing extra time to accomplish tasks, commanders can minimize errors and injuries.

HYPOXIA-RELATED ILLNESSES AND EFFECTS

1-39. Hypoxia, a deficiency of oxygen reaching the tissues of the body, has been the cause of many mountain illnesses, injuries, and deaths. It affects everyone, but some soldiers are more vulnerable than others. A soldier may be affected at one time but not at another. Altitude hypoxia is a killer, but it seldom strikes alone. The combination of improper nutrition, hypoxia, and cold is much more dangerous than any of them alone. The three most significant altitude-related illnesses and their symptoms, which are essentially a series of illnesses associated with oxygen deprivation, are:

- *Acute Mountain Sickness (AMS).* Headache, nausea, vomiting, fatigue, irritability, and dizziness.
- *High Altitude Pulmonary Edema (HAPE).* Coughing, noisy breathing, wheezing, gurgling in the airway, difficulty breathing, and pink frothy sputum (saliva). Ultimately coma and death will occur without treatment.
- *High Altitude Cerebral Edema (HACE).* HACE is the most severe illness associated with high altitudes. Its symptoms often resemble AMS (severe headache, nausea, vomiting), often with more dramatic signals such as a swaying of the upper body, especially when walking, and an increasingly deteriorating mental status. Early mental symptoms may include confusion, disorientation, vivid hallucinations, and drowsiness. Soldiers may appear to be withdrawn or demonstrate behavior generally associated with fatigue or anxiety. Like HAPE, coma or death will occur without treatment.

OTHER MOUNTAIN-RELATED ILLNESSES

1-40. Other illnesses and effects related to the mountain environment and higher elevations are:

- *Subacute mountain sickness.* Subacute mountain sickness occurs in some soldiers during prolonged deployments (weeks/months) to elevations above 3,600 meters (12,000 feet). Symptoms include sleep disturbance, loss of appetite, weight loss, and fatigue. This condition reflects a failure to acclimatize adequately.
- *Carbon monoxide poisoning.* Carbon monoxide poisoning is caused by the inefficient fuel combustion resulting from the low oxygen content of air and higher usage of stoves, combustion heaters, and engines in enclosed, poorly ventilated spaces.

- *Sleep disturbances*. High altitude has significant harmful effects on sleep. The most prominent effects are frequent periods of apnea (temporary suspension of respiration) and fragmented sleep. Sleep disturbances may last for weeks at elevations less than 5,400 meters (18,000 feet) and may never stop at higher elevations. These effects have even been reported as low as 1,500 meters (5,000 feet).
- *Poor wound healing*. Poor wound healing resulting from lowered immune functions may occur at higher elevations. Injuries resulting from burns, cuts, or other sources may require descent for effective treatment and healing.

ACCLIMATIZATION

1-41. Altitude acclimatization involves physiological changes that permit the body to adapt to the effects of low oxygen saturation in the air. It allows soldiers to achieve the maximum physical work performance possible for the altitude to which they are acclimatized. Once acquired, acclimatization is maintained as long as the soldier remains at that altitude, but is lost upon returning to lower elevations. Acclimatization to one altitude does not prevent altitude illnesses from occurring if ascent to higher altitudes is too rapid.

1-42. Getting used to living and working at higher altitudes requires acclimatization. Figure 1-8 shows the four factors that affect acclimatization in mountainous terrain. These factors are similar to those a scuba diver must consider, and the consequences of an error can be just as severe. In particular, high altitude climbing must be carefully paced and staged in the same way that divers must pace and stage their ascent to the surface.

- **Altitude**
- **Rate of Ascent**
- **Duration of Stay**
- **Level of Exertion**

Figure 1-8. Factors Affecting Acclimatization

1-43. For most soldiers at high to very high altitudes, 70 to 80 percent of the respiratory component of acclimatization occurs in 7 to 10 days, 80 to 90 percent of overall acclimatization is generally accomplished by 21 to 30 days, and maximum acclimatization may take several months to years. However, some soldiers may acclimatize more rapidly than others, and a few soldiers may not acclimatize at all. There is no absolute way to identify soldiers who cannot acclimatize, except by their experience during previous altitude exposures.

1-44. Commanders must be aware that highly fit, motivated individuals may go too high too fast and become victims of AMS, HAPE, or HACE. Slow and easy climbing, limited activity, and long rest periods are critical to altitude acclimatization. Leaves that involve soldiers descending to lower altitudes and then returning should be limited. Acclimatization may be accomplished by either a staged or graded ascent. A combination of the two is the safest and most effective method for prevention of high altitude illnesses.

- *Staged Ascent*. A staged ascent requires soldiers to ascend to a moderate altitude and remain there for 3 days or more to acclimatize before ascending higher (the longer the duration, the more effective and thorough the acclimatization to that altitude). When possible, soldiers

should make several stops for staging during ascent to allow a greater degree of acclimatization.

- *Graded Ascent*. A graded ascent limits the daily altitude gain to allow partial acclimatization. The altitude at which soldiers sleep is the critical element in this regard. Having soldiers spend two nights at 2,700 meters (9,000 feet) and limiting the sleeping altitude to no more than 300 meters per day (1,000 feet) above the previous night's sleeping altitude will significantly reduce the incidence of altitude sickness.

1-45. In situations where there is insufficient time for a staged or graded ascent, commanders may consider using the drug acetazolamide to help accelerate acclimatization; however, commanders must ensure soldiers are acclimatized *before* they are committed to combat. When used appropriately, it will prevent symptoms of AMS in nearly all soldiers and reduce symptoms in most others. It has also been found to improve sleep quality at high altitudes. However, commanders should consult physicians trained in high-altitude or wilderness medicine concerning doses, side effects, and screening of individuals who may be allergic. As a non-pharmacological method, high carbohydrate diets (whole grains, vegetables, peas and beans, potatoes, fruits, honey, and refined sugar) are effective in aiding acclimatization.

COLD

1-46. After illnesses related to not being acclimatized, cold injuries, both freezing and nonfreezing, are generally the greatest threat. Temperature and humidity decrease with increasing altitude. Reviewing cold weather injury prevention, training in shelter construction, dressing in layers, and using the buddy system are critical and may preclude large numbers of debilitating injuries. Figure 1-9 lists the cold and snow injuries most common to mountain operations. See FM 3-97.11 and FM 4-25.11 for information regarding causes, symptoms, treatment, and prevention.

- **Frostbite (freezing)**
- **Hypothermia (nonfreezing)**
- **Trench/immersion Foot (nonfreezing)**
- **Snow Blindness**

Figure 1-9. Common Cold Weather Injuries

1-47. Altitude sickness and cold injuries can occur simultaneously, with signs and symptoms being confused with each other. Coughing, stumbling individuals should be immediately evacuated to medical support at lower levels to determine their medical condition. Likewise, soldiers in extreme pain from cold injuries who do not respond to normal pain medications, require evacuation. Without constant vigilance, cold injuries may significantly limit the number of deployable troops and drastically reduce combat power. However, with command emphasis and proper equipment, clothing, and training, all cold-weather injuries are preventable.

SECTION III – EFFECTS ON EQUIPMENT

1-48. No manual can cover the effects of terrain and weather on every weapon and item of equipment within the Army inventory. Although not all-encompassing, the list at Figure 1-10 contains factors that commanders should take into account when considering the effect the mountainous environment may have on their weapons and equipment. Of these, the most important factor is the combined effects of the environment on the soldier and his subsequent ability to operate and maintain his weapons and equipment. Increasingly sophisticated equipment requires soldiers that are mentally alert and physically capable. Failure to consider this important factor often results in severe injury, lowered weapons and equipment performance, and mission failure. The information provided within this manual, combined with the information found in weapon-specific field manuals (FMs) and technical manuals (TMs), provides the information necessary to know how to modify tactics, techniques, and procedures to win on the mountain battlefield.

- **Operator/Maintenance Personnel**
- **Line-of-Sight**
- **Range**
- **Thermal Contrast**
- **Ballistics and Trajectory**
- **Target Detection and Acquisition**
- **First Round Hit Capability**
- **Camouflage and Concealment/Noise**
- **Mobility**
- **Wear and Maintenance**
- **Aerodynamics and Lift**
- **Functioning and Reliability**
- **Positioning/Site Selection**

Figure 1-10. Weapons and Equipment Factors Affected by the Environment

GENERAL EFFECTS

1-49. In a mountainous environment, the speed and occurrence of wind generally increase with elevation, and the effects of wind increase with range (depending on the speed and direction). Due to these factors, soldiers must be taught the effects of wind on ballistics and how to compensate for them. In cold weather, firing weapons often creates ice fog trails. These ice fog trails obscure vision and, at the same time, allow the enemy to more easily discern the location of primary positions and the overall structure of a unit's defense. This situation increases the importance of alternate and supplementary firing positions.

1-50. Range estimation in mountainous terrain is difficult. Depending upon the type of terrain in the mountains, soldiers may either over- or underestimate range. Soldiers observing over smooth terrain, such as sand, water, or snow, generally underestimate ranges. This results in attempting to engage targets beyond the maximum effective ranges of their weapon systems. Looking downhill, targets appear to be farther away and looking uphill, they appear to be closer. This illusion, combined with the effects of gravity, causes the soldier shooting downhill to fire high, while it has the opposite effect on soldiers shooting uphill.

1-51. Higher elevations generally afford increased observation but low-hanging clouds and fog may decrease visibility, and the rugged nature of mountain terrain may produce significant dead space at mid-ranges. These effects mean that more observation posts are necessary to cover a given frontage in mountainous terrain than in non-mountainous terrain. They also require the routine designation of supplementary firing positions for direct fire weapons. Rugged terrain also makes ammunition resupply more difficult and increases the need to enforce strict fire control and discipline. Finally, the rugged environment creates compartmented areas that may preclude mutual support and reduce supporting distances.

SMALL ARMS

1-52. In rocky mountainous terrain, the effectiveness of small arms fire increases by the splintering and ricocheting when a bullet strikes a rock. M203 and MK-19 grenade launchers are useful for covering close-in dead space in mountainous terrain. Hand grenades are also effective. Although it may seem intuitive, soldiers must still be cautioned against throwing grenades uphill where they are likely to roll back before detonation. Grenades (as well as other explosive munitions) lose much of their effectiveness when detonated under snow, and soldiers should be warned that hand grenades may freeze to wet gloves.

1-53. As elevation increases, air pressure and air density decrease. At higher elevations, a round is more efficient and strikes a target higher, due to reduced drag. This effect does not significantly influence the marksmanship performance of most soldiers, however, designated marksmen and snipers should re-zero their weapons after ascending to higher elevations. (See FM 3-25.9 and FM 3-23.10 for further information on ballistics and weather effects on small arms.)

MACHINE GUNS

1-54. Machine guns provide long-range fire when visibility is good. However, grazing fire can rarely be achieved in mountains because of the radical changes in elevation. When grazing fire can be obtained, the ranges are normally short. More often, plunging fire is the result (see Figure 1-11 and FM 3-21.7). In mountainous terrain, situations that prevent indirect fire support from protecting advancing forces may arise. When

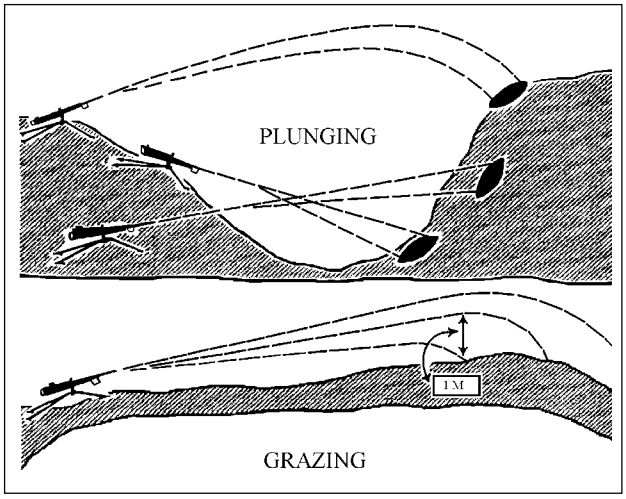

Figure 1-11. Classes of Fire with Respect to the Ground

these occur, the effects of machine-guns and other direct fire weapons must be concentrated to provide adequate supporting fires for maneuvering elements. Again, supplementary positions should be routinely prepared to cover different avenues of approach and dead space.

ANTITANK WEAPONS

1-55. The AT4 is a lightweight antitank weapon ideally suited for the mountainous environment and for direct fire against enemy weapon emplacements. Anti-tank guided missiles (ATGMs), such as the Javelin and the tube-launched, optically tracked, wire-guided, heavy antitank missile system (TOW), tend to hinder dismounted operations because of their bulk and weight. In very restrictive mountainous terrain, the lack of armored avenues of approach and suitable targets may limit their utility. If an armored or mechanized threat is present, TOWs are best used in long-range, antiarmor ambushes, while the shorter-range Javelin, with its fire-and-forget technology, is best used from restrictive terrain nearer the kill zone. However, their guidance systems may operate stiffly and sluggishly in extreme cold weather.

SECTION IV – RECONNAISSANCE AND SURVEILLANCE

RECONNAISSANCE

1-56. During operations in a mountainous environment, reconnaissance is as applicable to the maneuver of armies and corps as it is to tactical operations. Limited routes, adverse terrain, and rapidly changing weather significantly increase the importance of reconnaissance operations to focus fires and maneuver. Failure to conduct effective reconnaissance will result in units being asked to achieve the impossible or in missed opportunities for decisive action.

1-57. As in all environments, reconnaissance operations in a mountainous area must be layered and complementary in order to overcome enemy attempts to deny critical information to the friendly commander. In order to gather critical and timely information required by the commander, the activities of reconnaissance assets must be closely coordinated. Strategic reconnaissance platforms set the stage by identifying key terrain, as well as the general disposition and composition of enemy forces. Operational level commanders compare the information provided by strategic assets with their own requirements and employ reconnaissance assets to fill in the gaps that have not been answered by strategic systems and achieve the level of detail they require.

1-58. At the beginning of a campaign in a mountainous environment, reconnaissance requirements will be answered by aerial or overhead platforms, such as satellites, joint surveillance, target attack radar systems (JSTARSs), U2 aircraft, and unmanned aerial vehicles (UAVs). In a mountain AO, it may often be necessary to commit ground reconnaissance assets in support of strategic and operational information requirements. Conversely, strategic and operational reconnaissance systems may be employed to identify or confirm the feasibility of employing ground reconnaissance assets. Special reconnaissance (SR) and long-range surveillance (LRS) teams may be inserted to

gather information that cannot be collected by overhead systems, or to verify data that has already been collected. In this instance, satellite imagery is used to analyze a specific area for insertion for the team. The potential hide positions for the teams are identified using imagery and, terrain and weather permitting, verified by UAVs. See FM 3-100.55 for detailed information on combined arms reconnaissance.

1-59. In harsh mountain terrain, ground reconnaissance operations are often conducted dismounted. Commanders must assess the slower rate of ground reconnaissance elements to determine its impact on the entire reconnaissance and collection process. They must develop plans that account for this slower rate and initiate reconnaissance as early as possible to provide additional time for movement. Commanders may also need to allocate more forces, including combat forces, to conduct reconnaissance, reconnaissance in force missions, or limited objective attacks to gain needed intelligence. Based upon mission, enemy, terrain and weather, troops and support available, time available, civil considerations (METT-TC), commanders may need to prioritize collection assets, accept risk, and continue with less information from their initial reconnaissance efforts. In these cases, they must use formations and schemes of maneuver that provide maximum security and flexibility, to include robust security formations, and allow for the development of the situation once in contact.

1-60. Although reconnaissance patrols should normally use the heights to observe the enemy, it may be necessary to send small reconnaissance teams into valleys or along the low ground to gain suitable vantage points or physically examine routes that will be used by mechanized or motorized forces. In mountainous environments, reconnaissance elements are often tasked to determine:

- The enemy's primary and alternate lines of communication.
- Locations and directions from which the enemy can attack or counterattack.
- Heights that allow the enemy to observe the various sectors of terrain.
- Suitable observation posts for forward observers.
- Portions of the route that provide covert movement.
- Level of mountaineering skill required to negotiate routes (dismounted mobility classification) and sections of the route that require mountaineering installations.
- Suitability of routes for sustained combat service support (CSS) operations.
- Trails, routes, and bridges that can support or can be improved by engineers in order to move mechanized elements into areas previously thought to be impassable.
- Bypass routes.
- Potential airborne and air assault drop/pick-up zones and aircraft landing areas.

RECONNAISSANCE IN FORCE

1-61. The compartmented geography and inherent mobility restrictions of mountainous terrain pose significant risk for reconnaissance in force operations. Since the terrain normally allows enemy units to defend along a much broader front with fewer forces, a reconnaissance in force may be conducted as a series of smaller attacks to determine the enemy situation at selected points. Commanders should carefully consider mobility restrictions that may affect plans for withdrawal or exploitation. Commanders should also position small reconnaissance elements or employ surveillance systems throughout the threat area of operations to gauge the enemy's reaction to friendly reconnaissance in force operations and alert the force to possible enemy counterattacks. In the mountains, the risk of having at least a portion of the force cut off and isolated is extremely high. Mobile reserves and preplanned fires must be available to reduce the risk, decrease the vulnerability of the force, and exploit any success as it develops.

ENGINEER RECONNAISSANCE

1-62. Engineer reconnaissance assumes greater significance in a mountainous environment in order to ensure supporting engineers are properly task organized with specialized equipment for quickly overcoming natural and reinforcing obstacles. Engineer reconnaissance teams assess the resources required for clearing obstacles on precipitous slopes, constructing crossing sites at fast-moving streams and rivers, improving and repairing roads, erecting fortifications, and establishing barriers during the conduct of defensive operations. Since the restrictive terrain promotes the widespread employment of point obstacles, engineer elements should be integrated into all mountain reconnaissance operations.

1-63. In some regions, maps may be unsuitable for tactical planning due to inaccuracies, limited detail, and inadequate coverage. In these areas, engineer reconnaissance should precede, but not delay operations. Because rugged mountain terrain makes ground reconnaissance time-consuming and dangerous, a combination of ground and aerial or overhead platforms should be used for the engineer reconnaissance effort. Data on the terrain, vegetation, and soil composition, combined with aerial photographs and multispectral imagery, allows engineer terrain intelligence teams to provide detailed information that may be unavailable from other sources.

AERIAL AND OVERHEAD RECONNAISSANCE

1-64. During all but the most adverse weather conditions, aerial or overhead reconnaissance may be the best means to gather information and cover large areas that are difficult for ground units to traverse or observe. Airborne standoff intelligence collection devices, such as side-looking radar, provide excellent terrain and target isolation imagery. Missions must be planned to ensure that critical areas are not masked by terrain or other environmental conditions. Additionally, aerial or overhead photographs may compensate for inadequate maps and provide the level of detail needed to plan operations. Infrared imagery and camouflage detection film can be used to determine precise locations of enemy positions, even at night. Furthermore, AH-64 and

OH-58D helicopters can provide commanders with critical day or night video reconnaissance, utilizing television or forward-looking infrared.

1-65. Terrain may significantly impact the employment of overhead reconnaissance platforms using radar systems to detect manmade objects. These systems may find themselves adversely impacted by the masking effect that occurs when the mountain terrain blocks the radar beam. Thus, the radar coverage may not extend across the reverse slope of a steep ridge or a valley floor. Attempts to reposition the overhead platform to a point where it can "see" the masked area may merely result in masking occurring elsewhere. This limitation does not preclude using such systems; however, the commander should employ manned or unmanned aerial reconnaissance when available, in conjunction with overhead reconnaissance platforms in order to minimize these occurrences. The subsequent use of ground reconnaissance assets to verify the data that can be gathered by overhead and electro-optical platforms will ensure that commanders do not fall prey to deliberate enemy deception efforts that capitalize on the limited capabilities of some types of overhead platforms in this environment.

SURVEILLANCE

1-66. In the mountains, surveillance of vulnerable flanks and gaps between units is accomplished primarily through well-positioned observation posts (OPs). These OPs are normally inserted by helicopter and manned by small elements equipped with sensors, enhanced electro-optical devices, and appropriate communications. Commanders must develop adequate plans that address not only their insertion, but their continued support and ultimate extraction. The considerations of METT-TC may dictate that commanders provide more personnel and assets than other types of terrain to adequately conduct surveillance missions. Commanders must also ensure that surveillance operations are fully integrated with reconnaissance efforts in order to provide a3dequate coverage of the AO.

1-67. Long-range surveillance units (LRSUs) and snipers trained in mountain operations also contribute to surveillance missions and benefit from the restrictive terrain and excellent line-of-sight. Overhead platforms and air cavalry may also be used for surveillance missions of limited duration. However, weather may impede air operations, decrease visibility for both air and ground elements, and reduce the ability of ground surveillance elements to remain hidden for prolonged periods without adequate logistical support. As with overhead reconnaissance, terrain may mask overhead surveillance platforms.